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News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Building 101, Room E215, Gaithersburg, MD 20899-2500; telephone: (301) 975-3577.

ATOMS MIMIC LASER LIGHT IN FIRST-EVER MATTER WAVE MIXING EXPERIMENT

NIST physicists have opened a new field of physics with experiments demonstrating for the first time that atoms can display some unusual properties previously seen only with high intensity laser light waves. They report their findings in the March 18, 1999, issue of *Nature.*

Using sodium atoms cooled to very near absolute zero, the NIST team demonstrated that three atom waves can be mixed to produce a fourth wave, in exactly the same manner as optical laser beams can be combined to form a new laser light beam. These experiments, conducted in a vacuum, show that under very specific conditions, matter waves can mimic the way high-intensity laser light waves behave in certain materials.

"We are at the threshold of a new area of research: non-linear atom optics," says Nobel Laureate William D. Phillips, leader of the NIST Laser Cooling and Trapping Group.

Scientists expect that this new field of nonlinear atom optics will parallel the development of nonlinear optics, which emerged as scientists discovered many of the strange, unique and unexpected abilities of laser light following the demonstration of the first laser in 1960.

For more information and to see pictures of matter wave mixing, go to http://physics.nist.gov/atomoptics on the World Wide Web.

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GET A JUMP ON THE BUG WITH NEW NIST KIT

With everything from a self-assessment checklist to upgraded software, a new "Y2K Jumpstart Kit" now is available to help small businesses better deal with the year 2000 computer problem. The main component of the kit is software known as "Conversion 2000: Y2K Self-Help Tool." Developed last year by NIST, the software has been upgraded and now is available in both Microsoft Access™ and Excel™ versions.

The kit and software can help small manufacturers and other small businesses conduct an inventory of equipment; identify core business systems and rate their importance to the survival of the business; develop contingency plans; and plan and manage remediation projects.

The Y2K Jumpstart Kit can be downloaded for free from the Manufacturing Extension Partnership (MEP) web site at y2khelp.nist.gov. The kit also is available from MEP centers by calling (800) MEP-4MFG (800-637-4634) or by contacting offices of the U.S. Small Business Administration or the U.S. Department of Agriculture.

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SPRINKLER TESTING WITHOUT THE HIGH COST, MESS . . . OR THE FLAMES

NIST is creating a way to engineer the performance of fire sprinkler systems, a development that could make fire safety systems of the future better and more economical.

The Industrial Fire Simulator (IFS) combines computer technology, the latest advances in mathematical modeling techniques and measurements from controlled fire experiments conducted at NIST and elsewhere.

Researchers at NIST are developing the computer program and bench-scale measurement techniques to determine the burning properties of different fuels and spray properties of fire sprinklers.

The computer model will simulate fire spread and the response of a given sprinkler system. Engineers, building owners and local authorities will be able to specify input for the facility size and shape; its contents; and a proposed fire protection system, including sprinklers. The IFS produces video simulations of possible fire scenarios that can be viewed and quantified to evaluate the likely effectiveness of the proposed fire protection system.

NIST is partnering with the insurance and sprinkler industries to further develop this technology. Initially, this technology will be used in planning large-scale fire experiments with fire sprinklers.

Ultimately, the program will help fire protection engineers design more effective fire safety systems tailored to individual buildings.

NIST expects to make the first version of the IFS for fire sprinklers available by the end of the year.

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ANTENNA MEASUREMENTS FORTIFIED BY OATS

Electronic equipment manufacturers, antenna manufacturers, and calibration laboratories will be interested in a new NIST publication on electromagnetic compatibility testing and calibration. The document, Uncertainty Assessment for Standard Antenna Measurements on the Open Area Test Site (NIST Technical Note 1507), exhaustively analyses and quantifies the uncertainties of the standard (dipole) antenna method used on an open area test site, also known as OATS.

Testing on the OATS at NIST is conducted at frequencies between 30 MHz and 1 GHz and involves measuring the electric field using a standard antenna. The antenna under test is then substituted, and its response to the same field is measured. The uncertainties that can find their way into such a procedure are identified, explained and quantified, and the proper method for calculating the total uncertainty of the calibration is presented.

Copies of TN 1507 are available from Dennis Camell, MC 813.02, NIST, Boulder, CO 80303-3337; (303) 497-3214; camell@boulder.nist.gov.

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NEW PRIMER FOR "STEAM TABLES" HOT OFF THE PRESSES

Water, whether as a liquid or steam, is an important part of many chemical engineering processes. Representations of water's thermodynamic properties (known as "steam tables" are, therefore, vital tools for process engineers.

While the properties of water do not change over time, the state of the art for measuring and representing those properties does evolve. Unfortunately, many engineers are using steam tables developed in the 1960s or even as far back as the 1930s. Properties from these and other obsolete tables differ somewhat from those calculated from the current standards. The differences could introduce significant errors in research.

A new paper from NIST discusses current standards and where the differences in formulation might have significant effects. It also directs readers where to get further information on the properties of water and steam.

For a copy of paper No. 5-99, Keep Your "Steam Tables" Up to Date, contact Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3337; (303) 497-3237; sarabeth@boulder.nist.gov.

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PAPER HIGHLIGHTS HISTORY, IMPORTANCE OF IMPACT TESTING

A recent paper from NIST points out that one of the agency's most successful service programs—Charpy impact testing—has a long history in the field of testing and materials.

In 1905, French scientist Georges Charpy proposed a pendulum machine for measuring impact energy that is remarkably similar to present designs. In 1933, the American Society for Testing and Materials first published a standard test method for pendulum impact testing—named for Charpy—that, after numerous revisions and updates, is still in use today.

The need for impact testing was given a boost during World War II when fracture problems developed in merchant ships produced for the war effort. NIST's predecessor, the National Bureau of Standards, played a key role in understanding the failures when the agency's Charpy impact test was able to determine which hull plates were most subject to fracture. In the years that followed, the Charpy impact test was added to standards for the construction of bridges and pressure vessels.

Today, NIST's Standard Reference Materials Program sells over 12 000 Charpy impact specimens annually, while NIST's Charpy impact testing program serves 800 to 1000 customers a year.

For a copy of paper No. 10-99 on impact testing history, contact Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3337; (303) 497-3237; sarabeth @boulder.nist.gov.

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LOST IN TRANSLATION: $1 BILLION

More than the message gets lost in faulty translations of design information and other computer files exchanged among manufacturers. In the automotive industry alone, estimates a just-released study commissioned by NIST, "interoperability problems" when sharing product and engineering data impose annual costs totaling about $1 billion.

Resources expended to correct or re-create data files because of software incompatibilities account for more than 80 % of the total, states the study conducted by the Research Triangle Institute in North Carolina. Delays in the introduction of new vehicles are responsible for almost 10 % of the cost. Other expenses include purchases of different vendors' versions of software designed to perform similar tasks and spending for data-exchange services.

"Solving interoperability problems can improve competitiveness by reducing costs and cycle time," the study concludes.

The study also looks at various approaches to solving data-exchange problems. One potential solution is STEP, the evolving international STandard for the Exchange of Product model data, or ISO 10303. STEP is a neutral file format intended to support computer-to-computer exchanges of all types of product data, from initial design to maintenance requirements. NIST has been a significant technical contributor in the development of STEP as well as in other interoperability standards. NIST also develops test methods and software tools to facilitate industry's adoption and implementation of interoperability standards.

To request a single copy of Interoperability Cost Analysis of the U.S. Automotive Supply Chain (NIST Planning Report 99-1), contact Denise Herbert, NIST Program Office, (301) 975-2657, denise.herbert@ nist.gov.

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ATP TO HONE CUTTING EDGE AT FALL NATIONAL MEETING

Attendees from industry, academia and government will be able to sharpen their views on some of the nation's leading technology R&D opportunities at the Advanced Technology Program's (ATP) 1999 National Meeting, Nov. 15-17, 1999, in San Jose, CA.

Building on the theme "Accelerating Tomorrow's Technologies," the conference will feature in-depth workshops across many technology fields, including biosensors, tools for DNA diagnostics, adaptive learning systems, combinatorial chemistry, membrane separations, metabolic engineering, composite materials, high-temperature superconductors, intelligent control systems, motor vehicle manufacturing, surface engineering and semiconductor lithography. The meeting will track five main research topics: biotechnology, chemistry, information technology, electronics, and materials and manufacturing. Other sessions will examine ATP studies and economic assessments.

Highlights of the meeting will include an exhibit hall showcasing the results of successful ATP projects, opportunities for networking and workshops on the ATP application process, as well as strategies for moving the results of ATP research into the market and building industry/university collaborations.

For more information and to track schedule updates, visit the meeting web site at http://www.atp.nist.gov/ nationalmeeting/.

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NIST MODELS BENEFIT INDUSTRY, SOCIETY

Society has enjoyed important benefits from mathematical models developed by NIST that simulate the performance of electronic components called insulated-gate bipolar transistors (known as IGBTs), according to a recently completed analysis by the Research Triangle Institute of North Carolina.

The models were introduced in 1990. Since that time, the payoff to U.S. industry as a whole—and society in general—has been estimated at about 23 to 1, meaning $23 of benefits have been generated for every $1 spent on the modeling program. These benefits are based on the reduced cost of designing new products using simulation modeling.

IGBTs are electronic switches that enable sophisticated electronic circuits to use small amounts of electricity to control devices that require much larger amounts of electricity. Applications include automotive ignition systems, compressors for refrigeration and air conditioning, and "adjustable speed drives" that enable

electric motors to run more efficiently and provide more accurate control of precision equipment such as robotics and x-ray machines.

The mathematical models have helped industry decrease production costs. Consumers have enjoyed higher quality products at lower prices. The environment has benefited through the increased energy efficiency of products using IGBTs. They are used in software to simulate how IGBTs perform, enabling manufacturers to design and perfect "virtual prototypes" before investing in the parts, material and labor needed to build the actual prototypes.

Economic and social benefits are detailed in a report, Benefit Analysis for IGBT Power Device Simulation Modeling (NIST Planning Report 99-3), which may be downloaded from www.nist.gov/director/planning/strategicplanning.htm, or requested by e-mail to laura.gooding@nist.gov. Copies also are available through the NIST Inquiries Office, (301) 975-NIST, fax: (301) 926-1630, inquiries@nist.gov.
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WORKSHOP TO FOCUS ON PARCEL SHIPPING SCALE REGULATIONS

Billions of dollars worth of packaged goods are shipped between businesses and customers every year with fees based on the weight of the shipped goods. Established regulations and protocols exist to ensure the accuracy of all scales used in the United States for these business transactions.

However, in recent years, some package shipping services have claimed that another law, the Federal Aviation Administration Act of 1994, prohibits states from inspecting their scales. In response to concern from state inspectors, NIST's Office of Weights and Measures and the National Conference on Weights and Measures held a workshop to clarify inspection policies and related issues. This 1 day workshop was held in June 1999, at NIST in Gaithersburg, MD. Weights and measures officials, representatives of federal regulatory agencies, parcel shipping companies and other interested parties attended.

Presentations covered the U.S. system of measurement, weights and measures requirements, and inspection policies. Representatives of parcel shipping companies gave an overview of the industry and the FAA Authorization Act of 1994. Participants identified issues that needed resolution in order to ensure uniform national inspection policies.

The NIST Office of Weights and Measures provides technical advice and training to state, federal and industry representatives and, in collaboration with the National Conference on Weights and Measures, develops inspection procedures to assure accurate weights and measures. The National Conference on Weights and Measures is a voluntary standards organization that works closely with NIST to ensure uniform weights and measures in the United States.

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BIOMETRIC GROUPS MERGE, UNIFY INTERFACE DEVELOPMENT

The field of biometrics develops ways of identifying or authenticating a person by using distinguishing physical traits or behavioral characteristics such as fingerprints, hand geometry, iris structure, voice identification, facial characteristics, vein patterns found on the back of hand, and keystroke dynamics.

NIST recently played a key role in the unification efforts of two industrial groups developing biometric application programming interfaces (API). The merger of the Biometric API Consortium and the Human Authentication (known as the HA-API) Working Group will result in a unified biometric API development under a restructured Biometric API Consortium (Bio API).

The development of a single API assures biometrics application developers, service providers and users that require interoperable biometric solutions that the specification will receive broad industry input and review and will emerge as an international industry standard.

The agreement to merge was facilitated and organized by NIST and the Biometric Consortium. The Biometric Consortium serves as the federal government's focal point for research, development, test, evaluation, and application of biometric-based personal identification and verification technology.

The multileveled BioAPI is expected to bring platform and device independence to application programmers and biometric service providers. Current HA-API customers will be supported through the inclusion of HA-API function calls into the new BioAPI specification.

This new API development will facilitate the integration of biometric-based authentication services into leading computer security frameworks such as The Open Group's Common Data Security Architecture.

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NIST CONDUCTS INTERLABORATORY COMPARISON FOR MAGNETIC THIN-FILM HEAD METROLOGY

The need for standard magnetic reference materials in the hard disk drive manufacturing industry prompted NIST scientists to conduct an interlaboratory comparison of measurements on magnetic thin films. The round robin was sponsored by the National Storage Industry Consortium as part of its Head Metrology Requirements Roadmap project. Twelve laboratories participated in the study, with approximately equal representation from industry, academia, national laboratories, and instrument manufacturers. Nine different magnetic thin-film samples were fabricated at NIST and distributed to the participants. The samples included single-crystal nickel films sputter-deposited on diamond substrates and Ni-Fe films grown on silicon wafers. Measurements from four common magnetometers—induction-field, vibrating sample, SQUID, and alternating gradient force—were included. The interlaboratory comparison revealed the industrys immediate need for consensus standards consisting of Ni-Fe films on MgO substrates and, in the long term, NIST-traceable magnetic thin-film Standard Reference Materials.

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GAS-COUPLED ULTRASONICS FOR PIPELINE INSPECTION

Thousands of miles of large diameter pipelines that transport natural gas are kept safe by routine inspections by instrumented robots pushed through the pipeline by the flowing gas. The majority of these inspections are performed by magnetic techniques that detect corrosion pits by observing anomalies in a magnetic field applied to the pipe wall by an array of permanent magnets. NIST and the Gas Research Institute conducted a feasibility study to see if the permanent magnets mounted on conventional inspection robots could be simultaneously used for ultrasonic inspection. The results demonstrated that ultrasonic wave signals with sufficient amplitude to facilitate several types of inspections could be produced under operating pipeline conditions and that the ultrasound could interrogate the same volume of pipe wall as is sensed by the magnetic method. Thus, the same defect can be characterized simultaneously by both ultrasonic and magnetic energy.

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NIST HELPS INDUSTRY TO IMPROVE SOFTWARE QUALITY

The pressure of time-to-market in the software industry is challenging to those trying to maintain or improve software quality. NIST is tackling the problem of software quality using a three-pronged approach. The first prong is to develop conformance tests (a type of black-box testing) to software specifications. NIST researchers work with relevant industry participants to ensure that conformance tests are robust and effective. Experience has shown that if these tests are developed in parallel with an emerging standard, both the specification and the implementations of the specification are improved. See http://www.nist.gov/vrml for the VRML Conformance Test Suite (VTS).

The second prong is to provide diagnostic (also known as white-box) testing techniques so that developers can better analyze the behavior of their programs. One form of diagnostic testing examines a programs internal state while the program is executing. This differs from black-box testing, where the examination is focused on correct output from given inputs. NIST researchers have developed VMView, a Java trace tool, that allows developers to capture the internal state of the executing Java applications. The execution trace then can be analyzed for quality. VMView is found at www.nist.gov/vmview.

The third prong of NIST's approach is to develop new testing techniques that can help the industry maintain and improve software quality in the presence of increasing time and resource pressures. Researchers are developing tools and techniques to automatically generate software tests, including conformance tests, from formal specifications. Using formal specifications has the added benefit of improving the quality of the software specifications. See www.itl.nist.gov/div897/divproj.htm for information.

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INDUSTRY AND RESEARCH COMMUNITY TO BENEFIT FROM NIST PUBLIC KEY INFRASTRUCTURE (PKI) REFERENCE IMPLEMENTATION

NIST has announced the availability of reference implementation PKI components that provide a sound basis for determining the interoperability of PKI components and PKI-aware products during the development cycle. NIST distributes the reference implementation at no cost to researchers and product developers within the

United States and internationally. The reference implementation conforms to that in NIST Special Publication 800-15, Minimum Interoperability Specification for PKI Components (MISPC). The MISPC leveraged emerging standards from the Internet Engineering Task Force (IETF), the International Organization for Standardization/International Telecommunication Union (ISO/ITU), and the American National Standards Institute (ANSI) to form a comprehensive specification for interoperable PKI products.

The NIST reference implementation is a suite of software components for Windows 95, 98, and NT systems. The software is distributed as executables and source code on CD-ROM upon request (see http://csrc.nist.gov/pki/mispc/refimp). The software allows developers and integrators to test the interoperability of their systems against reference components in laboratory experiments. The source code serves as an additional reference for the interpretation of PKI standards.

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NIST DEVELOPS NEW METHOD FOR FLAME SUPPRESSION EFFICIENCY SCREENING

Halon 1301, CF3BR, is a mainstay in fire protection for facilities of high value, such as airplanes, ships, and museums. However, it is also a potent depleter of stratospheric ozone and has been banned from production as of January 1994. Research is identifying a number of gaseous and liquid candidate replacements. Many of these have been and will be discarded from further consideration based on available information. For the rest, screening tools are needed to enable rapid identification of those relatively few agents whose propriety should be investigated aggressively. These tools should be quick, inexpensive, and require little of the agent.

Under sponsorship from the Department of Defense Next Generation Fire Suppression Technology Program (NGP), NIST scientists have developed the first bench-scale screen for comparing the flame extinction performance of both gases and liquids. The suppressant, added to the air flow past a cylindrical porous plug burner, sharply blows off the leading edge of the flame. The flow facility and the burner also may be made suitable as a screening tool for powders. The system has been calibrated using chemicals of known suppression efficiency and has already been used for some experimental fluids. Fabrication drawings and an operations manual are being prepared for distribution to interested laboratories.

Additional information on the NGP can be found at www.dtic.mil/ngp/.

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HIGHLY DIRECTIONAL ATOM LASER DEMONSTRATED

NIST researchers have reported in the journal *Science* the recent demonstration of a well-collimated, quasi-continuous atom laser. An atom laser is a device that emits a highly coherent beam of atoms, in direct analogy to the emission of highly coherent light from an optical laser. The first atom laser was demonstrated in 1997 at a university, however, the NIST atom laser represents a significant advance in that its atoms stream forward in a chosen direction in a very narrow beam. The direction of the earlier atom laser beam was determined by gravity and had a big spread due to the ten-dency of the atoms to repel one another.

The source of atoms for the atom laser was from a gaseous Bose-Einstein condensate, a highly coherent form of matter first achieved in 1995 a NIST physicist and a University of Colorado physicist. The key development of the NIST atom laser compared to other atom lasers is the technique used to couple atoms out of the condensate. The NIST group used stimulated, optical Raman transitions to transfer condensate atoms out of the magnetic trap in which they are held, giving them a momentum kick in the process. This "kick" given to the atoms resulted in a highly directional, well-collimated beam of coherent atoms, where the direction and speed of the atoms are determined by the orientation and frequencies of the optical laser beams used for the stimulated Raman transition.

The highly coherent, directed output from an atom laser might lead to improvements in instruments that currently use an atomic beam, such as novel gyroscopes and atom interferometers used in research. In addition, atom lasers could find applications in atom holography, the creation of holographic images with atoms producing any picture or pattern desired on a flat surface.

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NONLINEAR MATTER WAVE OPTICS

Researchers at NIST have opened a new field of physics with experiments demonstrating for the first time that atoms can display some unusual properties previously seen only with high intensity laser light waves. In the first demonstration of nonlinear atom optics, which appeared as the cover story in the journal *Nature,* the NIST physicists observed four-wave mixing of matter waves. Using sodium atoms in a Bose-Einstein condensate, the NIST team demonstrated that three atom waves can be mixed to produce a fourth wave, in exactly the same manner as optical laser beams can be combined in certain nonlinear materials to form a new laser light beam. Unlike nonlinear optics with light

waves, however, the atom waves interact directly with each other and no material is needed.

Theorists at NIST first predicted that a collision of three interacting Bose-Einstein condensates with the appropriate momenta would result in the generation of a fourth condensate with different momentum. In order to observe such four-wave mixing of matter waves, the experimentalists started with a single condensate of sodium atoms and split it into three distinct wavepackets with different momenta. When the momenta were chosen so that the three matter waves were phase matched, a fourth wavepacket appeared with a different momentum.

Non-linear optics has been key in the development of quantum optics, and nonlinear atom optics might result in the analogous development of quantum atom optics. Another possible application is the amplification of matter waves, making a beam of atoms more intense by creating additional atoms that are exact copies of those in the original beam.

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NEW RESULTS FOR PLASMA SPRAYED COATINGS

Plasma spraying is a process for depositing coatings as protection against thermal loads, wear, and corrosion. As a result of this process, the coatings themselves have properties quite different from bulk materials of the same composition, as a consequence of porosity, anisotropy, and residual stress. Residual stresses are an important factor in determining the lifetime of sprayed deposits. With a knowledge of the residual stresses they produce, spray parameters can be adjusted to a level that is optimal for durability and service. In a collaboration between a university and NIST, residual stress determinations have been made by neutron diffraction, making it possible to nondestructively obtain data from the interior of these coatings. Combining measurements of coatings under load and a new theoretical approach, the observed anisotropy of the elastic constants of the coatings is now understood for the first time. Continued progress in this collaboration is expected to provide new insights into coating properties with importance, for example, in the automotive industry and power generation.

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NIST IDENTIFIES CERAMIC RESONATOR ALTERNATIVE FOR WIRELESS COMMUNICATIONS

Wireless applications that emerged in the 1990s increasingly exploit high-frequency and broadband spectral regions beyond 10 GHz. For example, automobile collision avoidance systems operate beyond 70 GHz, the Teledesic Earth-encompassing orbital satellite system is proposed to operate beyond 10 GHz, and the newly announced Teligent system, a point-multipoint telephone/internet combined package, operates between 14 GHz and 38 GHz. Dielectric ceramics serve as critical components in these systems as oscillators, resonators, and filters. For these high-frequency, high-power applications, the ceramics must exhibit moderate permittivities and extremely low dielectric loss. Currently, only a single ceramic system, i.e., $Ba_3MTa_2O_9$, where M is either zinc or magnesium, is available for designers of these systems. The principal commercial drawback of this system is that the raw material Ta_2O_5 is extremely expensive and serves as an unavoidable obstacle to the reduction of component costs. NIST researchers are actively investigating phase diagrams that may contain alternative, less costly compounds with properties similar to those of $Ba_3MTa_2O_9$ for use as high-frequency dielectric resonators. Recent results suggest that a two-phase ceramic mixture of Ca_2AlNbO_6 and $Ca_3Nb_2O_8$ may exhibit temperature-independent dielectric properties similar to those of $Ba_3MTa_2O_9$, and could therefore serve as a low-cost alternative for high-frequency ceramic resonators. Preparation and characterization of these mixtures is in progress in collaboration with scientists at NIST Boulder.

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NIST DEVELOPS ABSOLUTE MAGNETOMETER FOR CALIBRATION OF MAGNETIC MATERIAL STANDARDS

A new absolute magnetometer has been developed and placed in operation at NIST. This magnetometer provides for measurement of magnetic moments traceable to fundamental standards. A Faraday method is used, with the field gradient calibrated using three independent techniques: direct measurement with a Teslameter; a force measurement with a paramagnetic sample whose susceptibility has been determined absolutely using the Thorpe-Sentfle method; and a force measurement on a

high permeability sample with known geometry (and hence known demagnetizing factor). The absolute magnetometer will be used to certify Standard Reference Materials (SRMs) for use in the calibration of magnetometers. These SRMs are needed to calibrate commercial magnetometers used to measure the magnetic properties of magnetic recording materials, permanent magnets, magnetic shielding materials, etc. The increased interlaboratory accuracy that can be obtained using magnetic SRMs is becoming a critical factor as the uses of magnetic materials are expanding in many industries. The first standard to be issued will be a Ni sphere, similar to SRM 772, which has been unavailable for many years. This is a perfect sphere fabricated from high-purity nickel and has a saturation moment of about 3.5 mA · m^2 (3.5 emu) in a field of 0.5 T. Other materials to be issued will include a nickel disk and a very small YIG (yttrium iron garnet) sphere (approximately 0.6 mm diameter with a saturation moment of 25 mA · m^2). The latter standard will be useful for calibrating high-sensitivity instruments such as SQUIDs (superconducting quantum interference devices) and alternating gradient magnetometers. The nickel disks represent a geometry favored by the magnetic recording industry.

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NIST DEVELOPS NEW TECHNIQUES TO ADDRESS PRECESSION, ROTATION TIMES, AND HIGH COERCIVITY ISSUES

Since 1990, the density of magnetic recording bits in hard disk drives has increased at a compounded annual rate of 60 %. However, while storage densities have been increasing, so have data rates, at a 40 % compounded annual rate. Current data rates of 200 MHz will be as high as 1 GHz in 5 years. These advances are being driven by exponentially increasing demands for the storage and retrieval of multimedia information. The industry currently has worldwide annual sales of $35 billion. Another enabler for these advances is cost: the cost of mass storage to the consumer dropped from $7 per million bytes in 1990 to 3 cents in 1999. Working with the National Storage Industry Consortium, NIST developed several world-class measurement tools and techniques that address critical issues.

When thin Ni-Fe films of the type used in recording heads are switched rapidly, the process is not direct. Like a childs top, the individual magnetic vectors in a film undergo gyroscopic precession, which impedes fast switching. Researchers at NIST were able to coherently control the precessional dynamics by applying two field pulses with an adjustable delay between them on the order of 1/2 nanosecond. The field pulses were generated by current pulses in microwave coplanar waveguides, much as currents generate fields in actual recording heads. The technique uses destructive interference to cancel the two resulting out-of-phase magnetization precessions. Underdamped precessional ringing normally present in thin Ni-Fe films converts to critical damping and fast switching. These results helped to allay the concerns of recording-industry leaders that precessional effects could result in deleterious nonlinear transition shifts in disk drive systems.

Using optical and inductive techniques developed at NIST and the University of Colorado, the team investigated and detected rotation times of 200 ps for 60° rotations in recording head materials. The optical sampling technique known as the second-harmonic magneto-optic Kerr effect (SHMOKE) has measured switching speeds of 300 ps in 50 nm thick Ni-Fe films driven with pulsed magnetic fields. The inductive method, which uses coplanar waveguides, larger field pulses, and samples with larger anisotropy, detected rotation times of 200 ps for 60° rotations—five times faster than any previously measured rotation speeds. These measurements of magnetic rotation times in thin film Ni-Fe have unprecedented temporal, spatial, and dynamic resolution.

Another concern—fundamental limits to further increases in areal recording density—stems from the high coercivity of the magnetic media on the hard disk drive platter. As the rise times of write signals decrease below 10 ns, the switching speed of the media may greatly affect the time and field strength required to write bits. Two experimental techniques to characterize switching speed were developed. In the first technique, the team measured magnetic switching in media over nanosecond time scales using quantitative Kerr microscopy. They applied nanosecond field pulses to Co-Cr-Ta media that were located over the center conductor of a coplanar waveguide, then quantified the amount of magnetic reversal by measuring the remanent state at zero applied field using the Kerr microscope. In the second technique, developed in collaboration with a private company, pulses again were applied to media on coplanar waveguides but a scanning magnetoresistive head was used to quantify magnetic reversal, rather than a Kerr microscope. The second technique allowed the team to write actual bit transitions into the media and observe the effect of the high-speed pulses. High speed switching was measured as a function of bit density, revealing the effects of the bit demagnetizing fields on the reversal process. Both techniques are readily transferable to industry and have already engendered interest

among industry researchers. This work makes it possible to quantify the magnetic fields required for high fre-quency recording in next-generation disk drives.
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NIST DEVELOPS TESTING SOFTWARE THAT ADDRESSES $500 MILLION PROBLEM IN ELECTRONICS MANUFACTURING INDUSTRY

NIST responded to a request from the electronics manufacturing industry, specifically the Institute for Interconnecting and Packaging Electronics (IPC), to work on a major problem inherent in the process of transferring design information to manufacturing facilities. The problem stems from ambiguous data, incomplete data, or misinterpreted data files being transferred from design to manufacturing. At best, production must be delayed while any ambiguities are resolved; at worst, product must be scrapped due to misinterpretation of the data.

The IPC is a trade association representing more than 2300 companies worldwide. Its members include printed circuit board designers, fabricators, and assemblers. The GenCAM (Generic Computer Aided Manufacturing) standard being developed by the IPC is intended to improve the transfer of design information for electronic products from computer-aided design tools, to computer-aided manufacturing tools. GenCAM files may be used to request quotations, to order details specifically process-related, or to describe the entire product (printed circuit board and printed circuit assembly) to be manufactured, inspected and tested, and delivered to the customer. GenCAM also is able to add information to represent multiple imaging for panel and subpanel fabrication.

NIST staff have developed a Compliance Test Module (CTM) software program to support the GenCAM standard because the IPC feels it is key to the industrys deployment of the standard. One of the main problems with the standards predecessors was a lack of strong technical support, especially with respect to conformance testing tools. The lack of these tools led to misinterpretations by commercial implementers of earlier standards, which, in turn, hurt their adoption within the industry. CTM is scheduled for release in the first quarter of 1999. At present, the CTM verifies the syntax of the GenCAM file, but there are plans to investigate adding semantic testing and testing for a design's "completeness" in the future. The development of the CTM has also contributed to improvements in the standard itself. The work brought to light some ambiguity issues within the standard that were resolved by the development committee, which made the standard more robust.
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NIST'S VACUUM-GAP CAPACITOR MAY RESULT IN NEW PROTOTYPE STANDARD FOR CAPACITANCE

NIST researchers have developed a prototype for a capacitance standard based on counting electrons, which has been pushed to a relative uncertainty of about 10^{-6}.

The prototype standard combines two technologies developed at NIST, an electron pump and a vacuum-gap capacitor. The electron pump, a microcircuit that operates at temperatures below 0.1 K, passes and counts individual electrons with a relative uncertainty of 1×10^{-8}. The vacuum-gap capacitor, which is still in development, already meets several important criteria, including no measurable time dependence (drift) or frequency dependence of the capacitance value. Most important of its electrical characteristics is that it has extremely high electrical resistance; a lower bound for the resistance has been measured at $10^{19}\ \Omega$ (a world record). The capacitor is constructed of a special grade of copper, suitable for extremely low temperatures, along with sapphire standoff balls, which have excellent thermal conductivity at low temperatures.

In operation, electrons flow onto the vacuum-gap capacitor, which is maintained at 0.1 K. After placing about 100 million electrons onto the capacitor, the researchers measured the resulting voltage across the capacitor, that is, the ratio of the pumped charge to the measured voltage, $C = Q/V$. At present, the repeatability of the measurement of C is of the order of 10^{-6}. With improvements to room-temperature electronics, it is expected that the repeatability will be 10^{-7}. A comparison of the prototype standard with the best commercial capacitance meter shows agreement well within the 2×10^{-6} calibration uncertainty of the commercial instrument.

This standard is part of the evolution away from artifact standards and toward reproducible, easily transportable standards based on quantized properties of nature. In this case, the quantum property is the electron charge. Since the value of the vacuum-gap capacitor can be determined in situ using the electron pump, no artifacts are needed to realize the measurement. When perfected, the prototype standard could function as a primary standard for some laboratories
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ENERGETIC POLYATOMIC ION BOMBARDMENT FOR SURFACE ANALYSIS

Researchers at NIST are using secondary ion mass spectrometry (SIMS) to evaluate new approaches for analyzing organic and semiconductor surfaces by bombardment with energetic polyatomic (or cluster) primary ion beams. These new polyatomic cluster sources are demonstrating impressive increases in sensitivity and depth resolution compared to traditional SIMS sources.

In this novel approach, the conventional SIMS atomic ion beam is replaced with a focused polyatomic ion beam used to bombard the surface of a material to be analyzed in ultrahigh vacuum. The interaction of the polyatomic ion with the sample results in the erosion or sputtering of the sample surface accompanied by emission of characteristic secondary ions. These secondary ions are analyzed in a technique called secondary ion mass spectrometry to reveal the chemical composition of the sample. The motivation for bombarding with polyatomic ions, as opposed to the more commonly used monoatomic ions, is based on two aspects of the inter-action between a polyatomic ion and a solid surface. When a polyatomic ion collides with a surface, it dissociates into its constituent atoms, each atom retaining a fraction of the initial energy of the cluster. Since the depth resolution of most surface analysis techniques based on ion beam sputtering is directly related to the energy of the primary projectile, the use of polyatomic ions offers a potential method for obtaining ultrahigh resolution depth profiles. In addition, as a result of its low penetration depth, most of the energy of a polyatomic projectile is deposited very close to the sample surface which may result in large enhancements in the number of ions or molecules desorbed from the surface by each impact, thus improving sensitivity.

To explore these effects, a new type of ion source has been developed in collaboration with a private company. This ion source is used for generating beams of sulfur pentafluoride, SF_5^+. NIST studies comparing the SF_5^+ primary ion to Ar^+ or O_2^+ bombardment under identical conditions demonstrated that the polyatomic ion offered significant improvements in depth resolution for semiconductor and metal thin-film analyses. For organic surfaces, characteristic molecular ion signals were enhanced by two to three orders of magnitude. Even more interesting was the unexpected observation that intact, characteristic parent molecular ions can be detected while sputter-depth-profiling through organic thin films and polymers. This "Molecular Depth Profiling" represents a completely new and promising analytical capability.

The use of the SF_5^+ primary ion is currently complemented by the application of a second ion source that generates negative cluster ions. This ion source has been used to generate carbon cluster projectiles C_x^- (x = 1 to 11) that may offer even greater improvements in sensitivity and depth resolution. Development of advanced sources compatible with existing SIMS instruments is expected to increase the utility of SIMS for a broad range of surface and materials analyses.

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INITIAL "CHARTERS OF FREEDOM" ENCASEMENT DELIVERED

In collaboration with the National Archives, NIST is contributing to the re-encasement of the U.S. "Charters of Freedom"—the Declaration of Independence, Constitution, and Bill of Rights. The NIST project team successfully met the demands to deliver the initial encasement, "the manufacturing model," as scheduled in February 1999. The National Archives officially unveiled this model in March 1999.

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NIST AND A PRIVATE COMPANY DEVELOP LASER-BASED STEP GAUGE

NIST, in cooperation with a private company, is developing a laser-based step gauge capable of measuring distances up to 5 m. This development will assist U.S. manufacturers in evaluating very large coordinate measuring machines. A prototype of this system underwent preliminary testing by NIST staff members at the company in early 1999. Initial test results indicate that a relative uncertainty of 1×10^{-6} or less should be achievable with the system.

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PRODUCT DATA MANAGEMENT INTERFACE STANDARD REVISED

The Object Management Group (OMG) Product Data Management (PDM) Enablers Revision Task Force completed its work and delivered the revised specification to the OMG on Feb. 28, 1999. Product data management systems are the principal repositories for engineering data in manufacturing organizations in the 1990s, and the PDM Enablers standard specifies

interfaces to the services of PDM systems from engineering applications software. The revised specification will be balloted in the OMG for adoption as the replacement for the existing standard. The revision completes nearly a year of effort by representatives of six major PDM vendors, four major industrial users, and NIST to finalize the reference specification for the first implementations in product and the first interoperability tests. Releases of conforming implementations in PDM products are expected within the next six months.
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AUTONOMOUS DRIVING DEMO IMPRESSES U.S. AND GERMAN DEFENSE AGENCY SPONSORS

The NIST robotic HMMWV (High Mobility Multipurpose Wheeled Vehicle) drove off road at speeds up to 32 km/h, impressing attendees at the Autonav Internal Progress Review held Feb. 9-10, 1999, at NIST. Autonav is a collaborative agreement between the U.S. and German defense departments to develop the next generation of controllers for unmanned off-road vehicles.

During the demonstration, the robot vehicle drove fully autonomously at 16 km/h and drove with autonomous steering and manual speed control at 32 km/h. The vehicle drove through the fields of NIST, detecting and avoiding obstacles up to 50 m away. Passengers in the vehicle viewed displays of sensor outputs, obstacle maps, vehicle status, obstacle free paths, and the operators commanded paths. This was the first demonstration of the 4D/RCS-baseline perception and control system developed by NIST for Autonav.

The attendees learned about NISTs work on the current and future operator control units, world modeling and planning at various levels in the 4D/RCS control hierarchy, vehicle simulation, terrain classification, and a run-off road evaluation system.
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NIST MATHEMATICIAN COLLABORATES ON COMPUTATION OF THREE-DIMENSIONAL DIMER CONSTANT

Since 1938, physicists and mathematicians around the world have been trying to calculate a fundamental quantity known as the dimer constant. This year, a NIST mathematician and a mathematician from the Institute for Defense Analyses Center for Computing Sciences, obtained the three-dimensional constant using a unique computational approach.

The dimer constant describes the rate of growth of the number of ways to arrange dominos (in two dimensions) or bricks (in three dimensions) on a lattice of increasing size. Dimer constants provide key information related to fundamental models of materials and are factors in computing the partition function for the monomer-dimer system. From the partition function, all thermodynamic properties such as specific heat of a material can be computed from first principles. The two-dimensional constant was obtained analytically in 1961, while the three-dimensional problem has defied exact solution. The approximate solution is based on the use of importance sampling techniques to estimate the permanent of a related matrix efficiently. The computed value, which comes with rigorous error bars, far exceeds the accuracy of any previously obtained result. A paper describing the work appeared in the *Journal of Computational Physics* (Vol. 149, No. 1, February 1999).
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ACOUSTIC RESONATOR FOR MEASURING FORCE

Scientists from NIST and a university have been issued a U.S. patent for an ultrasonic device that measures force. The device uses noncontacting electromagnetic-acoustic transduction to excite resonant modes in a cylindrical load-bearing metal rod and measure the resonant frequency changes induced by applied stress (the acoustoelastic effect). One advantage of this device over conventional strain-gage load cells is its higher resolution. Also, since the resonant frequencies are properties of the load-bearing element, errors arising from coupling to the transducer and aging of the transducer are not issues, as they are for strain gages. Other advantages include insensitivity to bending moments and durability in harsh environments.
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NIST WORKSHOP IDENTIFIES NEEDS FOR HEART VALVE RESEARCH

A workshop hosted by NIST in December 1998, identified three issues that heart valve manufacturers viewed as critical for more rapid introduction of improved prostheses. These issues are: (1) measurement of residual stresses in mechanical heart valves, particularly as these stresses affect long-term reliability, (2) accelerated test ing for wear and durability, and (3) in vitro imaging of blood flow for both mechanical and bioprosthetic valves. The meeting was in response to the recommendations of an earlier workshop, held at NIST

in February 1998, to evaluate the current measurement methods and explore the possibility of cooperative research. Hence, the December meeting emphasized reviews and critiques of the current methods employed for reliability analysis, accelerated test methods for wear and durability of mechanical heart valves, fluid mechanics analyses, and imaging of fluid flow. Speakers from industry, the Food and Drug Administration, NIST, and the National Institutes of Health presented critiques, and NIST facilitated the discussions. Some issues common to both mechanical and bioprosthetic valves were raised by participants. The workshop stimulated exploratory experiments within NIST on residual stress measurement and flaw detection.
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PROCESS AND CONSTRUCTION INDUSTRIES EXPAND PARTNERSHIP WITH NIST

Based on the initial successes of its Cooperative Research and Development Agreement (CRADA) with NIST, the PlantSTEP industry consortium decided to expand its collaborative work program. PlantSTEP is a consortium of 20 companies that own, design, build, operate, and maintain process plants, e.g., pharmaceutical and chemical plants, and companies that supply equipment, materials, and information technology for the process and construction industries. The primary focus of Plant STEP is to develop and support implementation of international standards for data exchange and data sharing in the process and construction industries. NIST and PlantSTEP developed the first international standard for exchanging plant spatial information, ISO 10303-227, aka STEP Application Protocol 227 (AP 227).

NIST and PlantSTEP extended their CRADA for 4 years to:

- accelerate implementation and successful use of ISO 10303-227 by U.S. industry;
- develop test cases for assessing and demonstrating implementations of AP 227;
- extend ISO 10303-227 into a draft international standard for exchanging piping prefabrication and inspection information;
- review and comment on draft specifications for international standards relevant to the process and construction industries; and
- establish a global industry roadmap for the delivery and use of standards for data exchange and sharing.

The work of this collaboration is part of the NIST SIMA project, Product Data Standards for the Process Plant Industries.
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WORKSHOPS HOSTED ON TELECOMMUNICATION SYNCHRONIZATION

In cooperation with the telecommunications industry, NIST co-sponsored and hosted a "Workshop on Synchronization in Telecommunication Systems" on March 9-11, 1999 in Boulder. On March 12, immediately following this workshop, an additional 1-day "Workshop on Synchronization in Wireless Systems" was held. Both NIST staff members and industry representatives presented information and led discussion on a range of clock and timing issues critical to the operation of optical telecommunications and wireless systems. While the workshops focused on current system requirements, special sessions also considered emerging synchronization issues expected to be important in future systems. The 3-day workshop drew an industry participation of 53 people, and attendance at the new wireless workshop was 21 people.

The synchronization-workshop series, which started as a tutorial on timing concepts developed by NIST for the industry, has been evolving gradually toward greater control and input from industry. In fact, this marks the first year that the workshops were officially co-sponsored by the ANSI subcommittee (called T1X1) of the industry association.
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FIRST ROADMAP WORKSHOP FOR ENVIRONMENTAL SCANNING ELECTRON MICROSCOPY

NIST scientists participated in the First Environmental Scanning Electron Microscopy Roadmap Workshop, held at Leura, New South Wales, Australia, in February 1999. This meeting was held to establish the state of measurement science in this field, and included representatives from many different countries.

Environmental scanning electron microscopy (ESEM) involves a radical departure from conventional SEM, which requires high vacuum (≈1 mPa to 1 μPa) for operation. ESEM takes place at pressures ranging from 0.1 Pa to 2000 Pa in a variety of gas environments (e.g., water vapor, oxygen, nitrogen, reactive gases, etc.). In this pressure range, water can be maintained in a liquid-gas equilibrium with modest specimen cooling

(≈5 °C). Many specimens, which would undergo rapid and destructive outgasing in the conventional SEM, can be observed in a stable condition in the ESEM. The ability to control the specimen environment while observing morphology at nanoscale resolution and performing x-ray microanalysis makes ESEM an ideal tool to study dynamic chemical processes. For example, NIST scientists have monitored the growth of tin oxide layers on silicon substrates by chemical vapor deposition from an atmosphere of tetramethyl tin and oxygen maintained in the ESEM.

The ESEM has been established as a highly useful tool for more than 10 years, but many of the aspects of its operation are poorly understood. The purpose of the First ESEM Roadmap Workshop was to determine the present state of experimental and theoretical knowledge of ESEM, especially of primary and secondary radiation behavior, and to define a program of critical measurements necessary to advance the field. NIST contributions to the workshop were particularly directed at understanding remote electron scattering outside of the focused beam, especially how this process affects spatial resolution in x-ray microanalysis performed at elevated pressure.

Several workshop participants agreed to assemble basic data sets from critically reviewed experiments, with the objective of preparing a comprehensive ESEM text emphasizing basic theory, operations, and applications that will begin to establish consensus standards in this field.

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NEW METHODS TO IMPROVE SAFETY OF PRESSURIZED GAS TANKS

NIST scientists have initiated a cooperative effort with the U.S. Department of Transportation to evaluate new inspection procedures and develop appropriate reference standards for pressurized gas tanks used in the transportation industry. Serious safety considerations exist with the use of pressurized gas tanks since cracks in the tank walls can lead to catastrophic failure, as evidenced in the case of a 1997 Los Angeles explosion. With 22 major U.S. cities currently transforming their government vehicles, including school buses, to natural gas vehicles, increased emphasis and visibility have been placed on the safety issues. Whereas the reliable inspection of these tanks is obviously important, presently used visual inspection techniques have been found inadequate for crack detection. Ultrasonic inspection methods, in particular, may provide a promising approach for detecting these cracks in a rapid and reliable manner.

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NIST WORKS WITH DIGITAL TV ENVIRONMENT GROUP TO DEVELOP REFERENCE IMPLEMENTATION

NIST is working with the Digital TV Application Software Environment specialist group (called DASE or T3/S17) to develop a reference implementation of DASEs Application Programming Interface (API). The DASE API supports the construction of interactive, real-time TV features—an example is on-screen selection buttons—which will be included in future digital television broadcast materials. Members of DASE include various private companies and broadcast networks. The group accepted and approved the NIST statement of work and project schedule during its February 1999 plenary meeting in Los Angeles. NIST will develop a DASE API reference implementation to give proof-of-concept for the T3/S17 definition, to provide an impetus for conformance testing, to aid other DASE implementations, and to provide a standard environment for developing and testing DASE applications. The NIST implementation will be the reference benchmark for testing other implementations. It will include a Java version of the API, simulated and emulated Set-Top Units (STUs, which are the TVs computer), some sample applications, and a users guide.

DASE (T3/S17) has as its parent the Advanced Television Systems Committee (ATSC). ATSC has 171 corporate members in broadcasting, consumer electronics, computing, and feature productions for web and television. The committee was formed to establish voluntary technical standards for advanced television systems, including the digital high definition television (HDTV) format adopted by the FCC for American use. Canada, South Korea, Taiwan, and Argentina also subscribe to ATSCs HDTV format. Structured similar to ANSI committees, ATSC has first-level Technology Groups (e.g., T3 = Technology Group on Distribution) and second-level specialist groups (T3/S17 = DASE).

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NIST RESEARCHERS DOCUMENT SPEECH RECOGNITION BENCHMARK TESTS

NIST researchers presented the results of several recent benchmark tests involving automatic speech recognition (ASR) at the recent Defense Advanced Research Project Agency (DARPA) Broadcast News Workshop. Held in Washington, DC in early 1999, the workshop brought together approximately 125 researchers to focus on the development of automatic technologies to access broadcast news. NIST presented four technical papers at the workshop, documenting recent benchmark tests.

The first presentation reported on the research communitys success in automatic transcription of a 3 hour broadcast news test set prepared by the NIST group. Researchers at a private company reported the lowest word error rate, 13.5 %. Another considerably faster system, developed by researchers at a university achieved a word error rate of 16.1 %. A second paper reported on the success of researchers in "tagging" information carrying expressions (e.g., names, dates/times, and numbers) in the broadcast news transcriptions generated by ASR systems, a first step toward information extraction. Word error rates are approximately 20 % higher for these expressions. The third presentation, involving processing a corpus of some 54 000 stories collected over a 6 month period, reported on the results of research in topic detection and tracking. The fourth presentation summarized the results of Spoken Document Retrieval studies reported at the NIST-sponsored Text REtrival Conference (TREC-7) held at NIST in November 1998.

The NIST-developed Recognizer Output Voting Error Reduction (ROVER) software was incorporated in 5 of the 9 systems developed by participants in the primary systems comparisons. The ROVER software incorporates a sub-optimal high dimensional string alignment process to create a network and then implements a "voting" process to select a one-best hypothesis string. Using the ROVER approach to re-scoring the hypothesis files submitted by the test participants, NIST researchers demonstrated an overall word error rate of 10.6 %—21 % lower than the lowest word error rate achieved by the test participants.

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NIST WILL LEAD STUDY ON DANGER OF FIRE SMOKE

NIST and the Fire Protection Research Foundation are announcing a research initiative to study how smoke and heat impede escape and survival in fires.

The research will help policy makers determine whether, when, and how to incorporate sublethal effects of hot fire smoke in safety decisions. Sublethal effects are those that do not kill quickly.

Fire smoke consists of fine particles and hundreds of gases, some of which are toxic. Most fire deaths are due to smoke inhalation rather than burns from flames. Much is already known about how smoke inhalation can kill fire fighters and building occupants, but little information exists about more subtle effects of smoke exposure. These include mental disorientation, eye irritation, and coughing that make it difficult for someone to escape a burning building.

The data portion of the program will examine existing information on post-fire health effects and prior studies of laboratory animals exposed to gases typical of those in fire smoke. Fire scenario analyses will help determine the types of fires in which sublethal effects are likely to affect survival. Researchers will develop a standard method for measuring gases produced when everyday products burn and will construct a database of that information.

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QUALITY AND PERFORMANCE EXCELLENCE STAR IN FOUR-VIDEO SET

NIST has released a new four-video set showcasing the Baldrige National Quality Program. The first two videos are long and short versions of the program *Quest for Excellence XI.* Both spotlight the successful strategies of the 1998 Baldrige Award winners: Boeing Airlift and Tanker Programs, Solar Turbines Inc. and Texas Nameplate Company, Inc. Also included in the VHS package are two other videos: *A Journey Worth Beginning* that encourages organizations to consider applying for the award and *A Uniquely Rewarding Experience* that profiles the volunteer examiners who evaluate award applications.

The videos are available on VHS or CD-ROM for $20. Request copies from the American Society for Quality, 611 E. Wisconsin Avenue, Milwaukee, Wisc. 53202-4606, (800) 952-6587. The item numbers are T1076 for the VHS version and T1084 for the CD-ROM.

For more information, contact the Baldrige National Quality Program, (301) 975-2036, nqp@nist.gov, or see the BNQP web site at www.quality.nist.gov.

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PROMISING STRATEGY MAY HELP OVERCOME MEASUREMENT DILEMMA

As the features of electronic circuits continue to shrink, it becomes increasingly difficult to accurately measure their widths because images of object edges are inherently fuzzy at extreme magnification. Typical widths that need to be measured are about 0.5 μm. No microscope is perfect, so images always contain distortions at some level, and width measurements are particularly sensitive to these. With mathematical models of the instruments, the distortions can be corrected.

But how accurate are the models? The answer can be found only by testing the models with a sample for which the exact width is known. Unfortunately, there are no such samples; the inherent image fuzziness makes them hard to come by.

Now, researchers at NIST have taken a major step in solving that problem. Their solution is to make a sample that can be measured by different instruments that operate on completely different principles. Then, the image distortion is corrected with models developed at NIST (and in some cases, now commercially available). The better the results agree, the less likely that significant model errors exist.

NIST scientists have successfully measured a silicon sample with three types of measurement techniques: scanning electron microscopy, atomic force microscopy and a method called electrical critical dimension (or ECD) measurement, which determines the width of a feature by analyzing its electrical resistance.

The uncertainties for the first two instruments were a mere 5 μm and 13 μm, respectively. The electrical measurement technique yielded a higher uncertainty of 34 μm, possibly because the sample's low electrical conductivity made it less than optimal for this type of measurement. The next step will be to measure a sample with higher conductivity so that the ECD can be better measured.

For technical information, contact John Villarrubia, NIST, 100 Bureau Dr., Stop 8212, Gaithersburg, MD 20899-8212; (301) 975-3958, villar@nist.gov.
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RESEARCHER INVESTIGATES RELIABILITY PROBLEMS WITH FLIP-CHIPS

In an effort to make electronic circuit boards smaller, cheaper and faster, the electronics industry has gone to flip-chip-on-board technology. This means attaching silicon chips to printed wiring boards with solderballs. Increased speed is achieved by decreasing the distance between the chip and the substrate. This technology works well at temperatures from 20 °C to 120 °C but fails at an unacceptable rate when temperatures are reduced to – 55 °C.

Seeking the reason for the failure, a NIST researcher used the electron-beam moire technique to study local deformations in a flip-chip package and interactions among the various materials found within the package. As temperatures changed, images of the moire fringe patterns were acquired and compared. The package was subjected to 10 complete thermal cycles from – 55 °C to 125 °C over several days.

After only one complete thermal cycle, debonding initiated between the solderball and the solder mask where that interface meets the printed circuit board. This debonding continued to grow through the solder mask and into the underfill, then arrested after going one-quarter of the way around the solderball. At the end of the 10 cycles, holes about 200 nm across were found at other locations where the solderball/solder mask meets the printed circuit board. However, the holes never coalesced to form a crack. Deformation also was induced within the solderball, becoming more pronounced with more thermal cycles.

For a copy of two papers (listed as No. 17-99) discussing the flip-chip problems, contact Sarabeth Harris, MC 103, NIST, Boulder, CO 80303-3337; (303) 497-3237; sarabeth@ boulder.nist.gov.
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DOCUMENTS TELL HOW TO IMPROVE CAVITY MEASUREMENT ACCURACY

The air-filled stripline cavity is used widely in industrial laboratories for measuring the dielectric and magnetic properties of materials at radio frequency/microwave frequencies. The results of two recent NIST studies suggest that the measurement accuracy of this technique is unsatisfactory. The reasons: less-than-optimal perturbation of the internal cavity fields by the material specimens under test, failure to correct for magnetic depolarization errors (in complex permeability measurements only), and excessive radiation losses during dielectric measurements which create major errors in the estimation of losses.

Methods of improving measurement accuracy are suggested, including how to choose optimal specimen dimensions. The NIST studies are documented in three recent publications: NIST Technical Note 1505, Stripline Resonator for Electromagnetic Measurements of Materials; Paper 8-99a, Permittivity and Permeability Measurements Using Stripline Cavities—A Compari-

son; and Paper 8-99b, On RF Material Characterization in the Stripline Cavity.

All three documents are available from Claude Weil, NIST, MC 813.01, Boulder, CO 80303-3337; (303) 497-5305; weil@boulder.nist.gov.
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DIGITAL TELEVISION (DTV) COMES TO NIST

NIST became one of the first in the Washington Metropolitan Area to receive high-definition television (HDTV) broadcasts, which began in 10 major cities across the United States in November 1998. NIST scientists are developing new metrics for visual quality and fidelity for digital television and software reference implementations. The goals of this project are to provide general guidelines to ensure that content providers are guaranteed a level of quality for information rendered on a wide variety of displays and to develop a video database.

HDTV offers twice the vertical and twice the horizontal resolution of todays TV. Because of the higher aspect ratio for HDTV (16:9 vs 4:3 for conventional television), HDTV contains over five times as much picture information. The NIST research includes the display of HDTV broadcasts on a large rear projection screen, as well as on somewhat smaller plasma displays.

In conjunction with this research, NIST also is working with the Advanced Television Systems Committee Digital Television Applications Software Environment Specialist Group to develop a reference implementation of their Java-based Application Program Interface for future set-top boxes and content providers for DTV (HDTV is a subset of DTV) receivers. These set-top boxes represent the convergence of computing and consumer electronics, providing the viewer the ability to interact with the digital television receiver.
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NIST SOFTWARE HELPS POLICE PICK VEHICLES

Police departments in the United States spend more than $1.5 billion to purchase some 67 000 patrol vehicles each year. When deciding which vehicle to purchase, fleet managers must determine which vehicle best suits the needs of their department. AutoBid is a new software tool developed by NIST that makes this decision much easier.

Vehicle performance test data for police vehicles are published annually by the Michigan State Police. AutoBid gives fleet managers an easy way to use these test scores to pick the best vehicle for their needs. Users tell AutoBid how important each of the seven Michigan State Police performance test scores are by entering an importance weight for each score. AutoBid then computes a performance score for each vehicle and ranks the vehicles according to their relative performance. AutoBid also allows users to view the Michigan State Police performance test scores and detailed hardware specifications for each vehicle.

Future versions of AutoBid will include an additional method of vehicle selection using a combined score based on both vehicle cost and test scores. This method will identify which vehicle is the "Best Buy" in terms of the lowest cost for equivalent test performance and will rank the vehicles by the cost adjusted for performance.

Two versions of AutoBid are available. The AutoBid Applet Version can be viewed via a Java-enabled web browser such as the latest version of Netscape or Internet Explorer. The AutoBid Application Version runs on any operating system with the Java Runtime Environment installed. Both versions of AutoBid and the Java Runtime Environment are available from JUSTNET—National Law Enforcement and Corrections Technology Center, http://www.nlectc.org/autobid/overview.html.
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FIRST MEASUREMENT OF PROTOTYPE ELECTRICAL CRITICAL DIMENSION (CD) REFERENCE FEATURE MADE USING SILICON LATTICE AS RULER

For the first time, high-resolution transmission electron microscopy (HRTEM) imaging has revealed (111) lattice fringes spanning the entire width of a single-crystal CD reference feature patterned on a (110) silicon wafer. This image was obtained as part of a collaboration between NIST and Sandia National Laboratory. The objective of this very successful, long-term collaboration is to provide the semiconductor industry with reference artifacts for the calibration of the tools and processes used in the production of semiconductor devices.

The first test feature measured in this phase of the project is part of the new NIST-35 CD test-chip fabricated by Sandia using an innovative wafer-fabrication process. A preliminary lattice-plane count of the HRTEM image was made while viewing the image through an optical microscope. The width of the feature, approximately 580.5 nm, is currently at the upper end of interest for the semiconductor industry. Narrower

features, which can be imaged at higher magnifications, will be significantly easier to calibrate. A byproduct of this effort is that another procedure has been identified that eliminates the need to manually count the lattice-planes: staff at Los Alamos National Laboratory have digitized this first HRTEM image using a 3000 dots per inch drum scanner and have offered to digitize future images. Using the digitized images, exact lattice-plane counts then can be made using image-processing instrumentation at Sandia.

NIST researchers are committed to solving the problem of developing electrically testable structures that can be used in conjunction with HRTEM to provide low-cost reference materials. With this measurement, they have demonstrated that the width of a reference feature can be determined to an accuracy of several lattice-plane spacings, or approximately 1 nm. The final step in producing reference materials will be to reconcile the low-cost electrical measurements with the time intensive HRTEM measurements. Another major outcome of this work relates to the fact that it will be possible to provide the semiconductor industry with reference materials traceable to NIST. The materials under development now are expected to be useful through the generation of integrated circuits with 90 nm features, which will begin production around 2005. Currently, there is no other source available to support the implementation of future-generation lithography tools, such as 157 nm eximer-laser-based or extended ultraviolet lithography systems nor is there a measurement artifact available that can meet the demands of the worldwide semiconductor industry. NIST is understood to be the only likely source at present and in the near term.

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NEW PROCEDURE SOLVES LONG-STANDING PROBLEM ASSOCIATED WITH MAKING MULTIPORT ON-WAFER SCATTERING PARAMETER MEASUREMENTS

Microwave measurements previously made in coaxial or other waveguides are now made directly on-wafer whenever possible. However, the implementation of some of the more complex multiport measurements required to characterize complex electrical packages, multiconductor transmission lines, and multifunction circuits in the on-wafer environment has been hampered by the limitations of available probing systems, which do not allow direct connections between orthogonal probes during the calibration step.

In response to these difficulties, NIST scientists have developed a four-port test set and software for measuring fully corrected four-port on-wafer scattering and impedance parameters. The software is unique as it only requires two in-line calibrations, resolving an important difficulty with existing four-port calibration schemes. The additional hardware required to implement this method is inexpensive and easy to construct.

This new procedure allows calibrations for multiport measurements to be performed using well-understood-conventional in-line calibrations and provides the first solution to this long-standing problem. Not only is the method well suited to industrial environments, it also can be used to evaluate ad hoc methods commonly used in the industry to address this problem. The electronics packaging industry, which must often characterize multiport circuits, will probably benefit most from this software. In addition, the method probably will be applied to the characterization of multiport wireless circuits and digital transistors.

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NIST RESEARCHERS COLLABORATE WITH MICROWAVE MANUFACTURER TO CHARACTERIZE PROPERTIES OF NEW COMPOSITE MATERIAL

NIST staff collaborated with a leading microwave substrate and printed wiring board manufacturer to measure accurately the dielectric properties of a new composite material that consisted of randomly oriented ceramic particles in a polymer filler. The manufacturer needed measurements performed in the millimeter wave frequency range to meet the needs of electronic designers working at these frequencies. The selected measurement approach also provided the additional benefit of being able to demonstrate that the material is weakly anisotropic. The manufacturer had attempted to obtain such data at millimeter wavelengths from both industrial and academic testing laboratories, but the results obtained in prior efforts were inaccurate and inconclusive.

In preparation for the tests, the manufacturer etched 1.52 mm thick laminar sheets of the test material free of copper cladding and subsequently heat-bonded these together into a 48 stack layer to form a block that was 120 mm × 106 mm × 65.3 mm in size. Six slabs, approximately 12 mm thick, then were cut from the block along its three orthogonal *x-y*, *y-z*, and *z-x* planes. The slabs then were machined into discs that were 60 mm in diameter and about 3 mm thick. NIST measured the complex permittivity of the six disc specimens in a Fabry-Perot semi-confocal resonator at 60 GHz. Each specimen was measured four times, such that the resonator electric field was oriented either parallel or normal to the discs principal diameter, which

was defined as being parallel to the x-y plane of the laminar sheets. This yielded eight measurements each of the x, y, and z-directed components of complex permittivity. The measurement data then were returned to the manufacturer for further processing. After adjusting for variations in specimen densities, the manufacturer detected differences between the three components that were highly significant at a 98.5 % or greater confidence level. The differences between the x and y components of complex permittivity, relative to the z component were determined to be +1.8 % and +2.8 %, respectively, for relative permittivity, and +2.4 % and +4.3 %, respectively, for loss factor.
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NIST PROVIDES NOISE-TEMPERATURE MEASUREMENT SERVICE FOR SOURCES WITH 2.4 mm COAXIAL CONNECTORS

NIST staff have developed a new measurement service for the noise temperature of sources with 2.4 mm coaxial connectors. This type of connector and transmission line is used for applications as high as 50 GHz and is the most common coaxial size for the 26.5 GHz to 50 GHz frequency range. The connector geometry also is used extensively in measurement and test equipment, and high-speed digital logic, as well as for discrete components, such as switches, amplifiers, and mixers. The new measurement service essentially offers continuous frequency coverage from 8 GHz to 40 GHz and is capable of measuring sources with noise temperatures ranging from 50 K to 15 000 K. Typical expanded uncertainties ($k = 2$) are expected to be between 1 % and 1.4 % for frequencies as high as 26 GHz and between 1.5 % and 1.7 % for frequencies ranging from 26.5 GHz to 40 GHz. Noise temperatures for these sources would be approximately 5000 K to 10 000 K with a reflection coefficient of less than approximately 0.1.
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NIST DEVELOPS FIRST KNOWN PROTOTYPES FOR ON-WAFER DIODE NOISE SOURCES

NIST staff have designed, fabricated, measured, and characterized the first known prototypes for on-wafer noise sources. This effort provides the electronics industry with the only available means for establishing har-mony in on wafer thermal noise measurements. The three on-wafer noise sources were designed and fabricated using substrate structures and biasing circuitry provided by members of NISTs Industrial Monolithic Microwave Integrated Circuit Consortium.

Previous efforts by NIST researchers resulted in the development of techniques for the accurate measurement of noise-temperature on-wafer, and these methods were again used to evaluate the data from the prototypes. The earlier research also established accurate methods for the generation of on-wafer noise temperature from off-wafer sources, and these techniques were used to establish a check standard for verifying the measurements of the new noise sources. Data obtained from the study revealed that the three noise sources exhibit approximately constant noise temperatures, ranging from about 1000 K to about 10 000 K. The reflection coefficients were sufficiently small (<0.12) across the 8 GHz to 12 GHz frequency range. The team also identified some design improvements that will be incorporated in the next generation of on-wafer noise sources.
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BATTERY MATERIALS INVESTIGATED WITH NEUTRON BEAMS

Modern portable electronic devices require durable, lightweight batteries for convenient operation. Special materials are used for the electrodes of such batteries. The anode materials of choice in many lithium-ion batteries are various forms of disordered carbons, which are intrinsically light, and can reversibly take up and discharge lithium ions to very high densities. Physicists and materials scientists at NIST are using neutron inelastic scattering methods to study the structure of the disordered carbon materials and the location of absorbed lithium. They demonstrate that many carbons consist of microscopic irregular graphitic platelets, with their edges terminated by hydrogen atoms. Lithium is directly adsorbed onto the platelets, not into micropores between solid particles. The goal of this research is to understand why these materials have superior properties for lithium uptake and release, and how they might be improved.
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MANUFACTURE AND CERTIFICATION OF ELECTRODEPOSITED COATING THICKNESS STANDARDS

Improvements to the production, certification, and packaging of the Electrodeposited Coating Thickness Standard Reference Materials (SRMs) produced by NIST have been completed. These SRMs are used for the calibration of gages used to measure the thickness of

organic or nonmagnetic metallic coatings over magnetic materials, with steel being the most common substrate. The improved processes for production of these SRMs resulted from industrys demand for reference standards that could take advantage of the capabilities of modern magnetic induction thickness gages. The paint, electronics, aerospace, automotive, steel, and other industries need standards with more uniform thickness and smaller uncertainty in the certified thickness value.

These goals were met by changes in the SRM production process, which include increasing the thickness of the substrate material, redesigning the electrochemical cell used in production to increase deposit uniformity, increasing the area available for measurements, and packaging in a container that can be customized by the user. Significant changes also were made to the certification process of these standards. A new series of internal calibration standards was produced, the empirical mathematical models used to correlate thickness with magnetic induction intensity were revised, and the overall uncertainty of the standard was reduced by automating the measurement process. Total uncertainties for certified average thicknesses are reported as an expanded uncertainty at 95 % confidence around the mean thickness of the standard. The thickness variability within a given standard is reported separately on the certificate based directly on the measurements made on it. As a result of these improvements, the combined uncertainty of the mean thickness value for each standard has been reduced to less than 2 % of the certified value. The thickness standards now are marked with a bar code that allows tracking their complete history when they are returned for routine verification. A complete history of the degradation of the standard, as it is used in the field, will allow its life expectancy to be predicted.

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X-RAY TECHNIQUE OFFERS PROMISE AS MEASUREMENT FOR ELECTRONIC STRUCTURE IN CRYSTALLINE MATERIALS

Researchers from NIST and their collaborators from a university have measured the valence charge densities of Cu, Ge, and GaAs using a novel new technique in which valence-electron emission is measured in the presence of the x-ray standing-wave (XSW) field created by the interference of incident and reflected photon beams under Bragg diffraction. Understanding atomic bonding—ionic, covalent, or metallic—in a solid or film is a classical problem of solid-state physics. In general, the interaction among valence electrons may be described by the amount of charge transfer between the atoms and the degree to which this charge is localized within each bond. While x-ray diffraction has been one of the most important experimental tools for the study of the atomic-scale structure of solids, determining valence electronic structure lies at the limit of what x-ray diffraction can probe.

The difficulty encountered in x-ray diffraction measurements arises from the fact that all of the electrons within the unit cell contribute to the elastic scattering of photons; consequently, the elastic scattering arising from the valence electrons accounts for only a small fraction of the total diffraction signal. Additionally, because only the scattering amplitude is measured in a typical x-ray diffraction experiment, the phase of the Fourier component contributing to the scattering amplitude is lost.

These problems were circumvented by employing an electron analyzer to differentiate the valence-electron emission from the core-electron emission under condition of Bragg reflection. Because the valence electron-emission pattern is determined separately and is followed over the entire Bragg rocking curve, both the amplitude and phase of the diffracting Fourier component of the valence-charge density are determined via this technique.

The valence XSW results for Cu, Ge, and GaAs demonstrate that the phase of the reflection measured in this way is a direct, quantitative measure of the bond polarity, i.e., the degree of charge transfer between the atoms involved in the atomic bonding, while the amplitude of the reflection probes the spatial extent of the valence wave function. These results indicate that this new XSW technique offers a promise as a means for the direct measurement of spatially resolved electronic structure in crystalline materials.

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FERRITE STANDARDS ENTER SRM INVENTORY

NIST has completed certification of two new reference materials (RMs) intended for the calibration of instruments used to measure weld metal ferrite content in accordance with American National Standards Institute/American Welding Society (ANSI/AWS) Standard A4.2 and International Organization of Standardization (ISO) Standard 8249.

Secondary Ferrite Standards, RM 8480 and RM 8481, are designed for use in welding construction and repair applications where the ferrite content [indicated by ferrite number (FN)] of austenitic stainless steel welds must be controlled in tight ranges. RM 8480 consists of a low range (eight specimens distributed in the range of 0 FN to 30 FN) and RM 8481 is the corresponding high range (eight specimens distributed in the range of 30 FN to 120 FN).

The certification program required the development of an advanced calibration procedure and included more than 25 000 individual magnetic measurements before the data could be reduced into statistical summaries. The calibration procedure and statistical summaries are included in the RM certificates.

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PROVISIONAL PATENT ISSUED FOR TOOL TUNING SYSTEM

NIST researchers have demonstrated a simple approach—using a permanent magnet—for determining optimum machine parameters for high-speed machining operations. The system provides rotating tools with a once per revolution impulse and measuring response using capacitance gages. This simple system allows rapid assessment of the optimum stable speeds—and hence maximum removal rates—for a given cutting tool as mounted in the machine tool. This innovative method is faster and less expensive than other currently used methods for choosing optimal stable machining speeds. A provisional patent has been issued for this approach to enable further development and commercialization and NIST researchers are pursuing full patent approval.

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EXPRESS WEB SERVER RELEASED

NIST announced the web-based Express Web Server (http://www.nist.gov/express-server) for use by the ISO TC 184/SC4 (industrial automation systems and integration/industrial data) community. The server provides a web-based front end link to several software tools useful for developers and users of ISO 10303 (informally known as STEP—Standard for the Exchange of Product model data) and ISO 10303-11 (EXPRESS). The server also provides access to up-to-date EXPRESS files from various ISO 10303 series of parts and ISO 13584 series of parts. These are available for download, viewing, or for use with commands on the server.

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SUCCESSFUL STEP HEIGHT INTERCOMPARISON BETWEEN CALIBRATED STYLUS AND C-AFM

The calibrated atomic force microscope (C-AFM) continues to produce outstanding results. NIST researchers compared results of measurements of a 90 nm precision step obtained by two techniques. Using the C-AFM achieved a result of 90.78 nm $\pm$ 0.25 nm (coverage factor $k = 2$) from the C-AFM. In the C-AFM, a capacitance sensor, which is calibrated by comparison with a stabilized HeNe laser interferometer, measures the vertical displacements. Using the traditional stylus technique whereby a high-resolution stylus instrument, in this case a Talystep, is used to make a ratio measurement between the unknown step and a larger calibrated step height gave a result of 90.51 nm $\pm$ 0.85 nm. Therefore, the two results agree to less than 0.3 nm and are well within the combined measurement uncertainty. This is the third time within a year that sub-nanometer agreement in step height measurements between both instruments has been achieved. With these results in hand, the new 90 nm step now will be used as a calibration master for surface finish calibrations.

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VISUALIZATION OF VORTICES IN BOSE-EINSTEIN CONDENSATES

A NIST researcher created a rendering of a 3D Bose Einstein condensate under rotation. This involved visualizing a complex-valued function in three-dimensional space. The Bose-Einstein condensate visualization requires both two-dimensional and three-dimensional images. To produce a quality image, a transformation is needed that maps the data space onto a color space. More succinctly, a vector-valued function is used to map density and phase data onto the four-dimensional space: hue $\times$ saturation $\times$ value $\times$ opacity.

In general, the visualization technique centers on a (nonlinear) transformation from R^2 to R^4. As an example, the genration of a phase image requires a transformation from density $\times$ phase to the full range of hues. This follows from the need to see phase angles from 0 to 2π as a "color circle" where the algebraic identification of 0 and 2π is matched by a chromatic identification of corresponding colors. As another example, the three-dimensional images require that high-density areas are emphasized and low-density areas are suppressed. This is accomplished by mapping high-density areas to full value and opacity, while low-density areas are mapped to low value and opacity. The effect is that low-density areas are essentially made dark and transparent, thus revealing the high-density

areas as cloud-like regions of bright, colored light. In summary, since the transformations are based purely on mathematical functions, there is great latitude in producing a wide variety of images based on the same physical data.

This work was presented at the Workshop on Bose-Einstein Condensation and Degenerate Fermi Gases in February 1999, and in a display at the American Physical Society meeting in March 1999.

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FLAME RETARDANT PROJECT REACHES SUCCESSFUL CONCLUSION

NIST scientists have proposed a general mechanism for the fire retardant effect of silica gel in polymers. This is the result of a 2 year project supported by an industrial consortium. Most inexpensive, large volume commodity polymers are inherently flammable, and thus contain additives to meet safety requirements. Some of these additives contain halogens, which have raised environmental concerns, especially in Europe. Thus, U.S. manufacturers are seeking new, environmentally friendly flame retardants in order to manufacture the same products for export as well as domestic sale.

NIST scientists showed that the addition of silica gel to polypropylene, which is used extensively in upholstered furniture, carpets, cables, automobiles, etc., significantly increased the char residue and reduced the heat release rate, the most important factor in improving fire safety. The commercial firms were interested in learning how the additive worked so they might best use this in their products. It was found that the silica gel dramatically increased the viscosity of the melted polymer, reducing the transport of flammable organic fragments to the gas phase where they could mix with oxygen and burn. This inhibition is due to the hydrogen bonding of surface silanol groups and entanglement of polymer chains within the pore structure of the silica gel. Further, as the silica accumulated near the surface of the polymer, it formed a thermal insulation layer that reduces heat feedback from the flames.

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WORKSHOP HELD ON ELECTRICAL SAFETY SYSTEMS FOR THE AMERICAS

NIST and five private-sector organizations co-sponsored a one-week workshop on "Electrical Safety Systems for the Americas." This successful partnership among NIST, the National Electrical Manufacturers Association, the National Fire Protection Association, Underwriters Laboratories, Intertek Testing Services, and the International Code Council established an international forum on building codes, product certification, installation, and enforcement practices in several countries in the Americas.

Twenty participants from standards organizations, government agencies, and industry associations in Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela exchanged ideas with 25 representatives from counterpart U.S. organizations regarding existing systems in the hemisphere. The foreign participants gave presentations in their area of expertise as the workshop explored the different national schemes, seeking to identify future collaborations and the use of common criteria while achieving appropriate levels of protection and facilitating trade in the hemisphere. A visit to a construction site illustrated several key points made during the week by the U.S. representatives.

Participants resolved to facilitate further exchanges and collaborative efforts, including: (1) creating a virtual community for continuing discussions; (2) additional training and reviews of the National Electrical Code and the IEC 60364; and (3) advocacy within trade blocks, such as MERCOSUR, the Andean Pact, NAFTA, and the FTAA, of issues pertaining to the electrical sector.

The sponsors expressed hope that this unique and constructive workshop will mark the beginning of joint programs and ongoing activities among industry associations, government agencies, and standards organizations in the United States and participating countries in the Americas.

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SINO-U.S. WORKSHOP ON STANDARDS AND CONFORMITY ASSESSMENT HELD IN BEIJING, CHINA

A second Sino-U.S. Workshop on Standards and Conformity Assessment (the first having taken place in the United States) was held in Beijing, China in March 1999, to assist U.S. businesses interested in exporting to markets in China, and also to enhance mutual understanding in the harmonization of standards and the application of conformity assessment programs. The workshop, sponsored jointly by the Department of Commerce (NIST and the International Trade Administration) and China's Ministry of Foreign Trade and Economic Cooperation (MOFTEC), was very well attended and considered successful by both sides. The U.S. delegation of 44 persons represented seven product sectors

that were addressed in separate breakout sessions: construction codes and standards, electrical safety systems, boilers and pressure vessels, telecommunications, information technology, medical devices and diagnostic equipment, and automotive and off-road equipment. There were more than 300 other participants, primarily from Chinese agencies within MOFTEC and the Ministry of Construction.

A NIST web site, http://ts.nist.gov/ts/htdocs/210/216/china.htm, is being updated to provide summary information on the U.S. and China presentations, along with a list of workshop facilitators and presenters from each side. These individuals can be contacted for additional information.

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NIST CO-SPONSORS WORKSHOP ON LOW-LEVEL AND ENVIRONMENTAL RADIONUCLIDE MASS SPECTROMETRY AND ATOM COUNTING

NIST co-sponsored a workshop in April 1999, with the Council on Ionizing Radiation Measurements and Standards, and other Government agencies and private companies. Fifty participants attended the workshop to develop strategic plans to address the growing need for Standard Reference Materials (SRMs), certified reference materials (CRMs), and intercomparison and performance evaluation (PE) materials for low-level and environmental radionuclide atom counting.

Radionuclide measurement technology (mass spectrometry, accelerator mass spectrometry and fission track analysis) has advanced the forefront of metrology. The technology enables one to quantify the nuclide content of as few as 10^5 atoms in a sample, and isotopic ratios of 10^{-15}. However, SRMs, CRMs, and intercomparisons and PE materials are vitally important to provide a basis of credibility and data comparability. It was concluded from the workshop that:

- cross collaborations and integration are a must on an international, national, agency, program, and project basis;
- coordination should be established within the measurement community—including users, instrument manufacturers, and standards laboratories;
- the ANSI N42.23 concept of Reference and Monitoring Laboratories is necessary to address program and site specific quality assurance/quality control and reference material needs;
- SRM, CRMs, intercomparison, and PE materials must be characterized sufficiently to meet the needs of the programs they address per ANSI N42.22, and modified ISO 34 and 35; and
- ASTM and ANSI standards should be prepared to establish good technique practices for applications, data format, uncertainties, and intercomparison/PE material preparation protocols.

Detailed plans, collaborators, responsibilities, and schedules were developed for the production of primary and natural-matrix environmental SRMs, CRMs, intercomparison and PE materials containing actinides, long-lived fission products and cosmogenic nuclides over the next 10 years.

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NIST TO HOST THE INTERNATIONAL INTERCOMPARISON OF NIR SPECTRAL RESPONSIVITY AND REDUCED UNCERTAINTIES IN THE NIST NIR SPECTRAL RESPONSE SCALE

NIST has agreed to serve as the host laboratory for the Consultative Committee on Photometry and Radiometry (CCPR) international intercomparison of spectral responsivity scales in the near infrared (NIR), which is one of the CCPRs key comparisons. For this intercomparison, a number of indium gallium arsenide (InGaAs) photodiodes were purchased and their spectral responsivity measured in the Spectral Comparator Facility (SCF) over the wavelength range from 900 nm to 1600 nm. They have been measured twice, separated in time by approximately 6 months, to ensure their temporal stability.

A total of 16 laboratories are included in the intercomparison. A total of three rounds are planned, with one-third of the laboratories participating in each round. In January, the first set of InGaAs photodiodes was sent out to the first group of participating laboratories. They were due to be returned to NIST in April.

In preparation for the NIR Intercomparison of Spectral Responsivity, a new spectral responsivity scale was derived at the SCF, based on measurements using a lamp/monochromator system coupled to a cryogenic radiometer. The NIST researchers have reduced the uncertainties in the NIR spectral responsivity scale by approximately a factor of two over the wavelength range from 950 nm to 1600 nm. NIR spectral responsivity

measurements delivered through NIST calibration services have increased accuracy as a result of the new scale. In addition, InGaAs photodetectors were purchased to be used as new working standards at the SCF. These photodiodes were characterized extensively, and their spectral responsivity measured. They currently are being used as the working standards for the CCPR NIR intercomparison and for the calibration workload in the NIR region.

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Standard Reference Materials

SPARE THE ROD, SPOIL THE ACCURACY FOR FIBER MEASUREMENTS

Three standard reference materials (SRMs) relating to the diameter of coated optical fibers are available for sale through the NIST Standard Reference Materials Program. These SRMs are intended primarily for use in calibrating instruments that measure the diameter of coated optical fibers. Each SRM unit—consisting of an uncoated glass rod approximately 100 mm long and 250 μm in diameter—is individually certified for index of refraction and diameter. The index of refraction of the glass rod was chosen to match that of certain fiber coatings. Three indexes are available: 1.504 (SRM 2553), 1.515 (SRM 2554), and 1.535 (SRM 2555). Each rod is marked with a glued-on tab to assist in proper angular orientation during measurement. This flag also serves as the orientation reference for additional certified measurements at the angular positions indicated on the SRM certificate.

To order one or more of the standards, contact the SRMP, NIST, 100 Bureau Dr., Stop 2320, Gaithersburg, MD 20899-2320; (301) 975-6776; fax: (301) 948-3730; srminfo@nist.gov. Each SRM costs $363.

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Standard Reference Data

NEW NIST ATOMIC SPECTRA DATABASE CREATED

A new database has been created that makes a wealth of information on spectra, energy levels, and transition probabilities for atoms and atomic ions easily available via the World Wide Web. These data will be a valuable resource for many industrial applications and for interpretation of solar and other astrophysical spectra obtained from ground-based and space observations.

Version 2.0 of the Atomic Spectra Database (ASD) is accessible on the NIST website at http://physics.nist.gov/asd. ASD provides interactive capability that allows the user to choose the element or elements of interest and the type of data to be displayed. Default formats also are available for quick viewing of the data. The database provides full search and filter capabilities. ASD contains reference data that have been critically evaluated and compiled at NIST. Version 2.0 has data for about 950 spectra and about 70 000 energy levels. There are wavelengths for about 91 000 lines from 1 Å to 200 mm, with transition probabilities and estimated uncertainties for about half of these. Energy level data are available for most ions of the elements from H ($Z = 1$) to Kr ($Z = 36$), Mo ($Z = 42$), as well as up to the first five stages of ionization of the lanthanides ($Z = 57$ to 71). Wavelength data are available for all elements up to Es ($Z = 99$). For spectra of H ($Z = 1$) through Ni ($Z = 28$), the wavelengths are accompanied by line classifications and transition probabilities. Wavelength data from recent comprehensive NIST compilations of the spectra of Mg, Al, S, Sc, Be I, O II, and Ne I also are included. For the first five spectra of other elements wavelengths and relative intensities for prominent lines without classifications as published in Wavelengths and Transition Probabilities for Atoms and Atomic Ions (NSRDS-NBS 68) are given. References to the NIST compilations and original data sources are listed in a bibliography. This database is NIST Standard Reference Database 78.

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